Aguirre LLC's quantitative estimates for LNG carrier water use were derived from three sources; the Jordan Cove final EIS (FERC, 2009), the Broadwater LNG final EIS (FERC, 2008), and information provided by Oregon LNG in its application to the FERC (CH_2M Hill, 2008). Estimated cooling water intake rates ranged from a low of 0.3 million gallons per hour (mgh) (1,250 m^3/hr) based on diesel engine vessels using supplemental power from onshore facilities to a high of 2.6 mgh (9,800 m^3/hr). Similarly, the three sources indicate significant variation in ballast water intake rates from 0.7 to 1.0 mgh (2,600 to 3,900 m^3/hr). Table 4.3.1-4 summarizes the potential ranges of cooling ballast water and intake rates, volumes, and durations for the LNG carriers. Aguirre LLC indicated that, based on the type and size of the LNG carriers in the current fleet, the higher estimates in each case are most likely to be representative of the Project.

TABLE 4.3.1-4

Estimates of LNG Carrier Water Use and Intake Rates at the Offshore GasPort

Range	Time to Offload (hours)	Total time at AOGP (hours)	Ballast Intake Rate (mgh [m^3/hr]) [a, b]	Ballast Volume (million gallons [m^3])	Cooling Intake Rate (mgh [m^3/hr])	Cooling Volume (million gallons [m^3])	Total Intake Volume (million gallons [m^3])
Low	25	41	0.7 (2,600)	17.2 (65,100)	0.3 (1,250)	13.5 (51,100)	30.7 (116,200)
High	72	88	1.0 (3,900)	74.2 (280,900)	2.6 (9,800)	227.8 (862,300)	302.0 (1,143,200)

a All ballast intake occurs during offloading.
b Low value from FERC, 2009; high value from FERC, 2008.

LNG carriers would require about 17.2 to 74.2 million gallons (65,100 to 280,900 m^3) of water for ballast while offloading at the Offshore GasPort. Total cooling water intake volume would range from about 13.5 to 227.8 million gallons (51,100 to 862,300 m^3) during LNG delivery. Therefore, the combined water intake for ballast and cooling water for each LNG delivery would range from about 31 to 302 million gallons (116,200 to 1,143,200 m^3).

Seawater uptake by visiting LNG carriers would represent a negligible volume of water relative to the surrounding sea. For reference, the maximum 302 million gallons (1,143,200 m^3) required for ballast and cooling water represents the water contained in an approximately 340 cubic feet (9.6 m^3) of the Caribbean Sea in the vicinity of the Offshore GasPort.

Operation-Related Water Discharges

Of the Project's four principal facility components (i.e., FSRU, LNG carriers, offshore berthing platform, and subsea pipeline), only the FSRU and LNG carriers would have operation-related water discharge systems. The offshore berthing platform would be serviced via the FSRU systems. The heated water from the FSRU's engine cooling systems would represent the main water discharge during operation. LNG carrier discharges would be of similar volume to the FSRU discharges but with a smaller temperature rise relative to ambient sea temperature.

Water discharges have the potential to impact ambient water quality and biotic communities where discharge parameters fail to meet recognized standards and thresholds, generally embodied in regulations and permit conditions. Temperature standards are of particular significance here, based on the magnitude of the predicted cooling water discharges from the FSRU and LNG carriers. Residual chlorine standards are also relevant because several of the discharges would be treated with sodium hypochlorite as a biocide. Elevated temperature and chlorine levels can have sub-lethal or lethal effects on marine biota, depending on the magnitude and duration of the increase. Similar effects can occur if other contaminants, such as oil, grease, and metal particulates, are present in discharge water.

Floating Storage and Regasification Unit

During routine operations, the FSRU would operate with six permitted outfalls (001 through 006) and separate ballast outlets. Discharge sources for each of the outfalls (which correspond to functional use and/or derivation of discharged water, not necessarily actual discharge locations) are summarized in the following sections.

Outfall 001 – Main Condenser Cooling Water Discharge

The FSRU would utilize the steam from on-board boilers to drive the main turbine and turbo generators that provide power for the vessel's propulsion system, electric generation system, and auxiliaries. During vessel passage, which would occur when the FSRU first sails to the berthing platform and at intermittent times thereafter, seawater would be used to cool and condense exhaust steam in the vessel's main condenser, allowing heat dissipation. The same main condenser cooling system would operate during LNG transfer and regasification operations at the berthing platform.

The FSRU's main condenser cooling system would require the intake and discharge of approximately 47 mgd (177,900 m^3/day) of seawater during periods of normal capacity water use associated with LNG transfer and regasification. Intake water would circulate through the cooling system prior to discharge through a 55-inch-diameter (1.4 m) pipe (Outfall 001) on the side of vessel, 17.4 to 24.3 feet (5.3 to 7.4 m) below the ocean surface.

The JETLAG/VISIJET (JETLAG) Model (Lee and Cheung, 1990: Lee and Chu, 2003; Choi and Lee, 2007) was used to predict and analyze the spatiotemporal characteristics of the thermal plume associated with the discharge from the Main Condenser Cooling System. Parameters that were factored into the modeling include water discharge rate (momentum) and volume, thermal dissipation characteristics, and outlet port dimensions.

An elevation in water temperature of 21.6 °F (12.0 °C) above ambient (85.3 °F [29.6 °C]) was used to model the proposed mixing zone[5] for Outfall 001. This temperature increase was based on operating records for the Northeast Gateway Energy Bridge Project (EPA, 2007). Aguirre LLC assumed that this temperature differential (delta–t) would be representative of that associated with cooling water discharge from the Project's FSRU. Applying a delta-t of 21.6° F (12.0 °C), the maximum discharge temperature at Outfall 001 was estimated at 106.9 °F (41.6 °C). This maximum temperature was compared against a thermal compliance value of 90° F (32 °C), which is the EQB's ambient threshold that cannot be exceeded by the addition of higher temperature water other than through natural causes or by establishment of a permitted mixing zone (EQB, 2010b). The mixing zone was calculated to be a 135-foot (41 m) radius[6] from the outlet port based on EPA guidelines (EPA, 1991).

The result of the JETLAG modeling for the "no current" and "minimal current" scenarios (0.3 ft/sec [0.1 m/s]) are summarized in table 4.3.1-5. Under the "no current" scenarios, attainment of the 90 °F (32 °C) temperature criterion was calculated at a maximum horizontal distance of 33.7 feet (10.3 m)[7] from the discharge port and at a maximum depth of 22.8 feet (6.9 m). When modeled with a minimal current, the temperature criterion was attained at a maximum horizontal distance of 25.4 feet

5 A mixing zone is an allocated impact zone where water quality criteria can be exceeded as long as acutely toxic conditions are prevented (EPA, 1991).

6 Calculated based on 50 times the discharge length scale (2.7 feet [0.82 m]), which is the square root of the cross-sectional area of the discharge outlet (EPA, 1991).

7 All linear measurements for thermal plumes in this section are based on distance from the outlet port.

(7.8 m) and a maximum vertical depth of 23.4 feet (7.1 m). Therefore, the net increase in thermal loading is expected to have only a localized effect on water quality, well within the boundary of the 135 foot (41 m) mixing zone. The plume is predicted to dissipate beneath the FSRU's hull and not reach the seafloor.

TABLE 4.3.1-5

Temperature Criterion Attainment Profile for FSRU Outfall 001 Thermal Plume Based on JETLAG Model

Case	Discharge Depth (feet [m])	Ambient Velocity (ft/sec [m/s])	Temperature Criterion (°F [°C])	Horizontal Distance for Criterion Attainment (feet [m])	Water Depth for Criterion Attainment (feet [m])	Plume Contact with Seafloor
1	17.4 (5.3)	0	90 (32)	33.7 (10.3)	15.9 (4.8)	No
2	20.8 (6.4)	0	90 (32)	33.7 (10.3)	19.3 (5.9)	No
3	24.3 (7.4)	0	90 (32)	33.7 (10.3)	22.8 (6.9)	No
4	17.4 (5.3)	0.3 (0.1)	90 (32)	25.4 (7.8)	16.6 (5.0)	No
5	20.8 (6.4)	0.3 (0.1)	90 (32)	25.4 (7.8)	20.0 (6.1)	No
6	24.3 (7.4)	0.3 (0.1)	90 (32)	25.4 (7.8)	23.4 (7.1)	No

Under the NPDES, a permitted mixing zone would be inherently protective of area-wide water quality and thermal discharges from Outfall 001 (and Outfall 002) as they would have to comply with applicable regulatory requirements. Operation of the FSRU would be authorized by the EPA (the NPDES authority in Puerto Rico) only if the modeled mixing zone meets these requirements.

To prevent macrofouling of the FSRU's raw water intake systems, the FSRU would inject chlorine in the form of a sodium hypochlorite solution (approximately 0.5 ppm) into the sea chests to act as a biocide. The electrolytic generation system on board the FSRU would produce a continuous supply of sodium hypochlorite. The chlorine would disperse naturally within the water intake systems. The EQB water quality standard for residual chlorine in Class SC waters is currently under revision to limit concentrations to 0.011 ppm. The EQB will regulate residual chlorine in the water quality certificate based on the water quality standard in effect at the time of issuance of the water quality certificate. The EPA's recommended water quality criteria for residual chlorine are 0.013 ppm for continuous maximum concentration and 0.007 ppm for continuous chronic concentration in marine waters (EPA, 1986). These criteria are published pursuant to Section 304(a) of the CWA and provide guidance for states and tribes to use in adopting water quality standards. The in-pipe residual chlorine levels would range from 0.1 to 0.15 ppm, which exceeds both the current EQB and EPA standards. This residual chlorine concentration is not expected to significantly affect water quality due to the low concentration of sodium hypochlorite that may be present in the discharge and the relatively localized zone of initial dilution. All operational discharges would be subject to the requirements of the NPDES permit for the Project.

Outfall 002 – Auxiliary Cooling Water Discharge

Aguirre LLC used the JETLAG model to determine the thermal discharge plume associated with the auxiliary cooling water discharge from Outfall 002. Based on a similar FSRU currently in operation, a delta-t of 11.0 °F (6.5 °C) above ambient temperature was assumed. As such, at an ambient temperature of 85.3 °F (29.6 °C), the calculated maximum discharge temperature at Outfall 002 is 96.3 °F (35.7 °C). The mixing zone was modeled to be a 47.5-foot (14.5 m) radius[8] from the outfall based on EPA guidelines (EPA, 1991).

[8] Calculated based on 50 times the discharge length scale (0.95 feet [0.29 m]), which is the square root of the cross-sectional area of the discharge outlet (EPA, 1991).

The result of the JETLAG modeling for the "no current" and "minimal current" scenarios (0.3 ft/sec [0.1 m/s]) are summarized in table 4.3.1-6. Under the "no current" scenarios, attainment of the 90 °F (32 °C) temperature criterion was calculated at a maximum horizontal distance of 5.0 feet (1.5 m) and a maximum depth of 27.3 feet (8.4 m). With a minimal current of 0.3 ft/sec (0.1 m/s), attainment of the 90 °F (32 °C) criterion was predicted within a maximum horizontal distance of 4.1 feet (1.3 m) and a maximum depth of 27.3 feet (8.4 m). Therefore, the net increase in thermal loading is expected to have only a localized effect on water quality, well within the boundary of the 47.5 foot (14.5 m) mixing zone. The plume is predicted to dissipate beneath the FSRU's hull and not reach the seafloor. Plume parameters developed under the "no current" and "minimal current" scenarios are summarized in table 4.3.1-6.

TABLE 4.3.1-6

Temperature Criterion Attainment Profile for FSRU Outfall 002 Thermal Plume Based on the JETLAG Model

Case	Discharge Depth (feet [m])	Ambient Velocity (ft/sec [m/s])	Temperature Criterion (°F [°C])	Horizontal Distance for Criterion Attainment (feet [m])	Water Depth for Criterion Attainment (feet [m])	Plume Contact with Seafloor
1	20.4 (6.3)	0	90 (32)	5.0 (1.5)	20.4 (6.3)	No
2	23.9 (7.4)	0	90 (32)	5.0 (1.5)	23.9 (7.4)	No
3	27.3 (8.4)	0	90 (32)	5.0 (1.5)	27.3 (8.4)	No
4	20.4 (6.3)	0.3 (0.1)	90 (32)	4.1 (1.3)	20.4 (6.3)	No
5	23.9 (7.4)	0.3 (0.1)	90 (32)	4.1 (1.3)	23.9 (7.4)	No
6	27.3 (8.4)	0.3 (0.1)	90 (32)	4.1 (1.3)	27.3 (8.4)	No

Outfall 003 A (Port) and B (Starboard) – Water Curtain

For safety purposes it is common practice for most LNG vessels to maintain a constant flow of water, referred to as a "water curtain," over the deck and hull of the vessel during LNG transfer or regasification. In the event of a LNG leak during these operations, the presence of the water curtain helps protect the metal hull from any potential cracking or stress. The LNG vessel would use seawater withdrawn through the high and low starboard and port sea chests, pumped onto the deck of the FSRU at a flow rate of approximately 0.6 mgd (2,270 m^3/day), and then discharged over the port and starboard sides of the vessel as runoff. As discussed above, water within the FSRU's internal piping system would be subject to treatment with sodium hypochlorite for biofouling control. We anticipate that these levels would diminish shortly after discharge and would not significantly affect water quality. We do not anticipate these discharges would result in any change in ambient temperature. All operational discharges would be subject to the requirements of the NPDES permit for the Project.

Outfall 004 A (Port) and B (Starboard) – Freshwater Generator

The seawater supply for the freshwater generator would enter the FSRU through the high and low starboard and port sea chests. Approximately 0.3 mgd (1,135 m^3/day) of seawater would be withdrawn and piped to the freshwater generator, which would produce approximately 0.03 mgd (115 m^3/day) of freshwater. The FSRU would discharge the remaining 0.27 mgd (1,020 m^3/day) as brine water, which would exhibit slightly higher salinity content than the surrounding surface waters due to the concentrating effects of freshwater removal.

Consumptive uses of the generated freshwater would include on-board potable supplies for drinking water and sanitary purposes, feed water for the main and auxiliary boilers, and make-up water. Any surplus freshwater would be stored on the vessel or discharged.

The freshwater generator and piping would be treated with sodium hypochlorite. Some residual chlorine may be present in the 0.27 mgd (1,020 m^3/day) of seawater that would pass through the freshwater generator without desalinization prior to discharge through the Outfall 004 discharge points on the starboard and port sides. Given the very low discharge volume relative to the oceanic receiving waters, the high brine concentration and possible residual chlorine are not expected to result in noticeable water quality impacts. All operational discharges would be subject to the requirements of the NPDES permit for the Project.

Outfall 005 – Ballast Water Systems

The FSRU would discharge ballast water in response to ongoing FSRU operations and vessel stability needs during the LNG loading and regasification processes. Ballast discharge volumes could reach 1.9 mgd (7,200 m^3/day) but would vary according to operational status and sea conditions. An MGPS would be developed to minimize the potential for macrofouling of the onboard ballast system. Intermittent biocide treatment of the ballast tanks would involve the injection of chlorine, derived from the vessel's electrolytic sodium hypochlorite generation system. We anticipate that these levels would diminish shortly after discharge and would not significantly affect water quality. Given that the ballast water for the FSRU would be withdrawn and discharged at the same Offshore Gasport location, there would be no possibility of invasive species being introduced through the release of ballast water originating from another location.

The FSRU would undergo dry-dock maintenance about every 5 years. During scheduled dry-dock periods, PREPA may require Aguirre LLC to use a similar FSRU to meet contractual send-out rates. The commissioning of the new and/or returning FSRU would likely require the discharge of ballast water from an offsite location. Due to the infrequency of these discharges and the fact that Aguirre LLC must comply with USCG's ballast water discharge requirements, we do not anticipate any significant impacts on water quality. All operational discharges would be subject to the requirements of the NPDES permit for the Project.

Outfall 006 Stormwater

Under normal operation conditions, dust and dirt are expected to accumulate on the decks and other exposed services of the FSRU. In addition, minor leaks of grease and other lubricants from on-board equipment could occur. When raining, these materials could become entrained in sheet-flow runoff from the decks, resulting in intermittent releases to the surrounding waters of the Caribbean Sea. To minimize impacts associated with stormwater discharges, Aguirre LLC would implement measures outlined its Stormwater Pollution Prevention Plan, including the deployment of equipment drip vats and oil absorbent material around collection drains. We conclude that implementation of these measures would minimize the likelihood of stormwater impacts on the Caribbean Sea. All operational discharges would be subject to the requirements of the NPDES permit for the Project.

Hoteling and Sanitary Treatment System

Operation of the FSRU would generate galley, hotel services, and sanitary wastes. Water contributing to these wastes would be freshwater generated by the FSRU's on-board desalination system. Assuming 10 percent of the freshwater is used for sanitary system support, the FSRU would generate approximately 0.03 mgd (115 m^3/day) of black and gray wastewater from the restroom, hoteling, and galley services.

The FSRU would treat and manage wastewater on a daily basis in compliance with regulations set forth by the 1978 Protocol of the 1973/78 International Convention for the Prevention of Pollution from Ships (MARPOL, Annex IV). Under MARPOL, the FSRU would be required to have an approved on-board system to treat and disinfect sewage before offshore discharge or would need to store and periodically off-load sewage to a service vessel for transportation to a land-based treatment facility. Aguirre LLC has indicated that all black and gray wastewater would be treated by an on-board septic system then pumped to a service vessel and taken onshore for eventual disposal. This would preclude any water quality impacts associated with offshore discharge.

Bilgewater and Blowdown Water Management

The bilge is the lowest compartment of a ship's hull, below the waterline, where the two sides meet at the keel. Deck water from precipitation, heavy waves, and other sources that does not drain directly over the sides of the ship would drain down through the ship's interior into the bilge. The collected water must be pumped out periodically to maintain the ship's full stability and operational capacity. Bilge water contains materials that are washed off the drained surfaces. These materials, some of which may be derived from leaks and spills, can include oil, grease, detergents, solvents, and particulate matter (e.g., metallic particles [including rust] and dirt).

Bottom blowdown refers to the periodic removal of accumulated particulates, sludge, and other impurities from the bottom of a ship's boilers to facilitate safe operation and efficiency. These impurities, which include rust and other metallic particles, pH adjustment compounds, and anti-scaling agents, can become concentrated during continuing evaporation of steam. Without blowdown, this concentration can compromise the boiler's steam generation capacity and structural integrity.

USCG regulations (33 CFR 151.10) require ships to comply with specific conditions for marine bilge discharges when operating within 12 nautical miles (22 km) of the nearest land. These conditions relate to the oil content and origin of the bilge water and the use of monitoring, alarm, and oil-water separation equipment. Oily water that fails to meet specified treatment standards must be containerized and stored for off-vessel removal and treatment at an onshore certified treatment facility. In consideration of these conditions, Aguirre LLC has indicated that bilge water collected from the FSRU bilge sump pumps, together with comingled bottom blowdown water from the main and auxiliary boilers would be pumped off the FSRU for onshore disposal at a Puerto Rico government approved facility. As part of this process, residual oil and grease would be concentrated and containerized. The absence of any offshore discharge would preclude ambient water quality impacts.

<u>LNG Carriers</u>

The condenser cooling water system would be the dominant discharge associated with the LNG carriers while moored at the offshore berthing platform. Aguirre LLC used the same JETLAG modeling system for the thermal plume characteristics of the LNG discharge as was used for the FSRU. Intake and discharge parameters were identical to those selected for the FSRU, except for a slightly higher maximum volume intake rate and a maximum delta-t of 5.4 °F (2.8 °C), which is based on off-loading characteristics from the Jordan Cove LNG Project (FERC, 2009).

The results of the JETLAG modeling for the LNG carrier discharges under the "no current" and "minimal current" scenarios are summarized in table 4.3.1-7. The modeling showed a confined plume with EQB's temperature criterion (90 °F [32 °C]) attained at 2.7 feet (0.8 m) in the horizontal plain and up to 26.7 feet (8.1 m) in the vertical plain; under the minimal current scenario (0.3 ft/sec [0.1 m/s]), the temperature criterion was attained at 1.3 feet (0.4 m) in the horizontal plain and at up to 25.4 feet (7.7 m) in the vertical plain. Therefore, the temperature criterion is met close to the discharge outlet under both current scenarios. However, the elevated flow rate is projected to impact the seafloor across all discharge depths and under both current scenarios, with consequent implications for sediment resuspension.

TABLE 4.3.1-7

Temperature Criterion Attainment Profile for LNG Carrier Thermal Plume Based on the JETLAG Model

Case	Discharge Depth (feet [m])	Ambient Velocity (ft/sec [m/s])	Temperature Criterion (°F [°C])	Horizontal Distance for Criterion Attainment (feet [m])	Water Depth for Criterion Attainment [a] (feet [m])	Plume Contact with Seafloor
1	17.2 (5.2)	0	90 (32)	2.7 (0.8)	19.8 (6.0)	Plume periphery
2	20.6 (6.3)	0	90 (32)	2.7 (0.8)	23.4 (7.1)	Plume periphery
3	24.0 (7.3)	0	90 (32)	2.7 (0.8)	26.7 (8.1)	Plume periphery
4	17.2 (5.2)	0.3 (0.1)	90 (32)	1.3 (0.4)	18.5 (5.6)	Plume periphery
5	20.6 (6.3)	0.3 (0.1)	90 (32)	1.3 (0.4)	22.1 (6.7)	Plume periphery
6	24.0 (7.3)	0.3 (0.1)	90 (32)	1.3 (0.4)	25.4 (7.7)	Plume periphery

[a] Depth is projected attainment of temperature criterion, plume momentum would impact bottom.

Cooling water discharges from LNG carriers would have to comply with applicable water quality criteria. Anti-fouling agents similar to those discussed for the FSRU above would be used by the visiting LNG carriers. We anticipate that these levels would diminish shortly after discharge and would not significantly affect water quality. Given compliance with EQB's temperature criterion of 90 °F (32 °C) is reached close to the point of discharge, we do not anticipate that elevated temperature levels would constitute a significant water quality impact. Whereas thermal plume modeling suggests that sediment resuspension could be a recurring phenomenon, with each visiting ship (approximately one every 8 days) discharging cooling water for the duration of its stay (up to approximately 88 hours), the effects would be localized and relatively minor.

As discussed above, the LNG carriers would take on ballast water to maintain stability and operational readiness as their cargo is off-loaded. However, ballast water discharges are not anticipated during the off-loading process. Similarly, LNG carriers would not conduct routine blowdowns while at berth.

4.3.2 Onshore Surface Water Resources

4.3.2.1 Regional Characteristics

The Jobos Bay watershed, which is defined as the entire land area draining directly to Jobos Bay, covers 53 mi^2 (137 km^2) and is bordered by two perennial stream networks: Rio Nigua to the west and Rio Guamani to the east. The watershed's northern boundary begins in the foothills of the Central Interior Mountain Range and the southern boundary extends for about 28 miles (45 km) along the mainland coastline of the bay (Zitello et al., 2008).

Freshwater surface discharges to Jobos Bay from the adjoining watershed are limited to one major perennial river (Rio Seco, 2.3 miles [3.7 km] east of the Aguirre Plant), several small intermittent streams, and diffuse overland runoff. Due to the dry climate, the streams exhibit intermittent flow throughout the year without any seasonal emphasis. Year-round flow is also limited where the streams meet highly porous fan delta deposits and water infiltrates downwards, contributing significantly to groundwater recharge in the underlying aquifer (Quiñones-Aponte et al., 1997).